FERMILAB
ACCELERATOR DIVISION
MECHANICAL SUPPORT DEPARTMENT

Debuncher RF & Cavity LCW Cooling System

SPECIFICATION #

1302 -ES- 296070

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1. INTRODUCTION

This specification describes the mechanical requirements for the operation of the Debuncher RF and Cavity Low Conductivity Water (LCW) cooling system. The overall system contains two integrated subsystems which provide cooling for the linac upgrade debuncher T.V. klystron and also for the debuncher cavity. Procedures for startup, continued operation, and solutions to possible failures of critical components in the cooling system are included.

2. OVERVIEW

The purpose of the Debuncher RF and Cavity LCW cooling system is to provide 95 F LCW cooling to the debuncher T.V. klystron and the correct temperature LCW for the debuncher cavity dependent on the cavity resonant frequencies. The overall system contains two subsystems which are the Debuncher RF and the Debuncher Cavity water systems. The Debuncher Cavity subsystem is a water skid identical to the transition water skids covered in Specification #1302-ES-296036 titled Linac Upgrade Module Temperature Control System authored by J. Satti and will not be discussed in this specification except where necessary at the interface of the two subsystems.

The Debuncher RF water skid contains a 10 Hp motor close coupled to a centrifugal pump providing approximately 60 GPM with a head of 230 feet of water. An identical motor and pump are connected in parallel in the system as a backup. The LCW system is a closed loop with cooling provided by a plate heat exchanger and 5 GPM of 55 F LCW (provided by CUB) removing the heat. A two way valve governs the amount of water passing through the heat exchanger by means of an automatic controller monitoring the temperature of the supply LCW. Approximately 5 GPM of the LCW cooling water is diverted through filters and deionization bottles in a polishing line to keep the water "clean" and an expansion tank provides a constant positive pressure on the suction of the operating pump. Flow meters, thermocouples, pressure transducers, and resistivity probes monitor information necessary to provide the correct LCW cooling in the most efficient way.

The 2 inch stainless steel piping from the Debuncher RF water skid traverses the booster gallery and enters the room containing the T.V. klystron through a penetration in the wall. The pipe is situated along one side of the klystron and ball valves are available for connection to the ports of the klystron. Each supply is equipped with a flow restrictor and strainer and each return contains a flow meter. The connections are made with hose and quick disconnect fittings. In instances where the T.V. klystron is disconnected from the water system, a back pressure regulating valve has been installed at the end of the 2 inch pipe run. The back pressure regulating valve is necessary to maintain a steady pressure and flow in the system in case the pump is not turned off.

In addition to supplying cooling for the T.V. klystron, a portion of the LCW water passing through the heat exchanger is also diverted to the Debuncher Cavity skid. The water is approximately the same temperature as the 55 F LCW cooling water in the heat exchanger. A control valve in the Debuncher Cavity skid regulates the amount of water diverted and the pressure supplied by the Debuncher RF water skid is sufficient to accommodate the needs of both systems.

During failure of any component in the Debuncher LCW cooling system, procedures will be followed to minimize down time of the klystron. Maintenance of the water skids will be expedited with the use of the available parallel backup pump, isolation valves, spare parts, and spare water skids in the case of the Debuncher Cavity water system.

3. DRAWINGS

The following drawings pertain to the Debuncher RF and Cavity LCW cooling system:

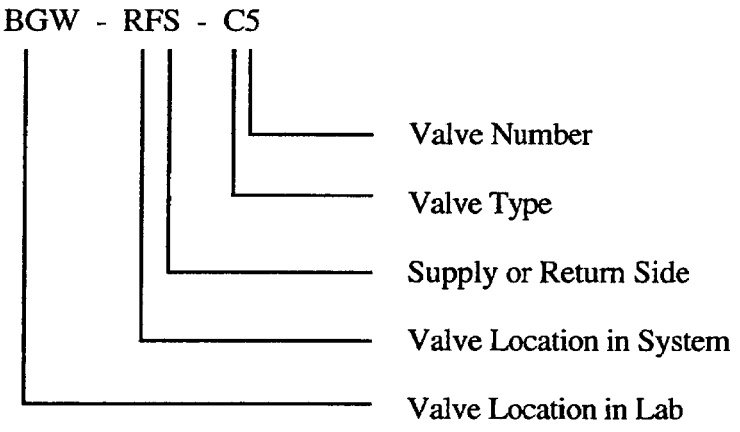
Drawing #	Title
0360.270-ME-299823	Linac Upgrade Debuncher LCW Cooling Skid Layout
0230-ME-300707	Linac Upgrade Booster Lab 7/ Debuncher Power Supply TV Klystron Cooling Piping
0260.000-MD-300731	Linac Upgrade Debuncher LCW Cooling Tank Assembly
0360.270-ME-299822	Debuncher Water Skid Unistrut Frame Welded Unit

4. PROCEDURES

During various phases of commissioning and operation of the linac upgrade project, procedures will be required to maintain the LCW system to accomplish proper cooling of the linac upgrade Debuncher RF components and cavity. In the following subsections, these procedures have been arranged in a checklist format for clarity.

Identification of valves in the system is necessary to perform maintenance procedures and each valve has been marked as follows:

Example valve label:



With Valve Types as follows:

B - Butterfly
P - Pressure Regulating
R - Relief
C - Check
G - Globe
T - Three Way
NO DESIGNATION - Ball

With Valve Location in System as follows:

RF - Water skid for RF components.
CA - Water skid for cavity.
TV - T.V. klystron

With Valve Location in Lab as follows:

BGW - Booster Gallery West

In the following procedures, the Lab location (BGW) designation has been purposely omitted since all valves covered by this specification are located in the Booster Gallery West. Refer to Figure 1thru 4 for a skid schematic and valve locations in the skid configuration.

FIGURE 1 SKID SCHEMATIC

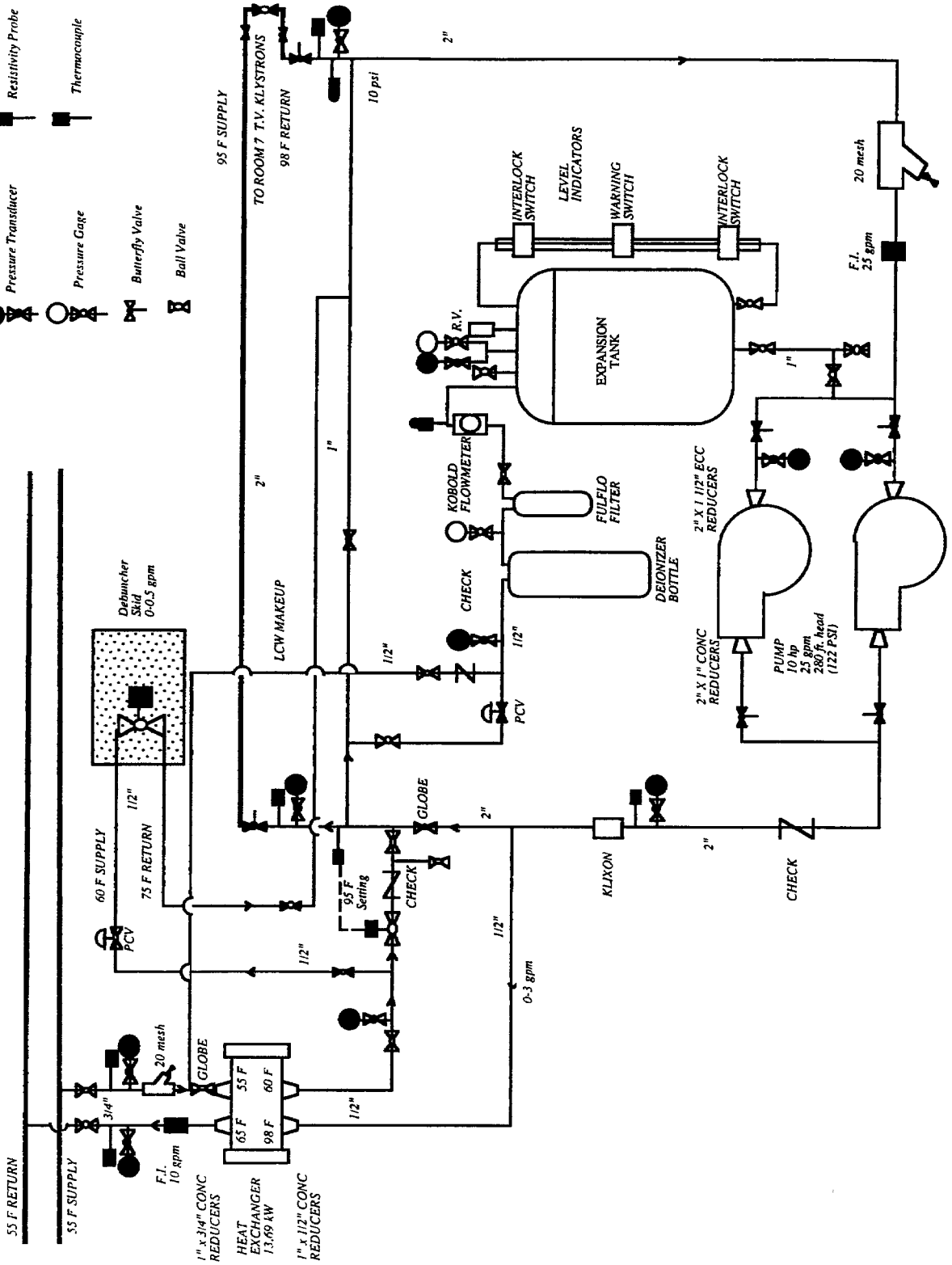


FIGURE 2 DEBUNCHER RF SKID VALVE LABELS

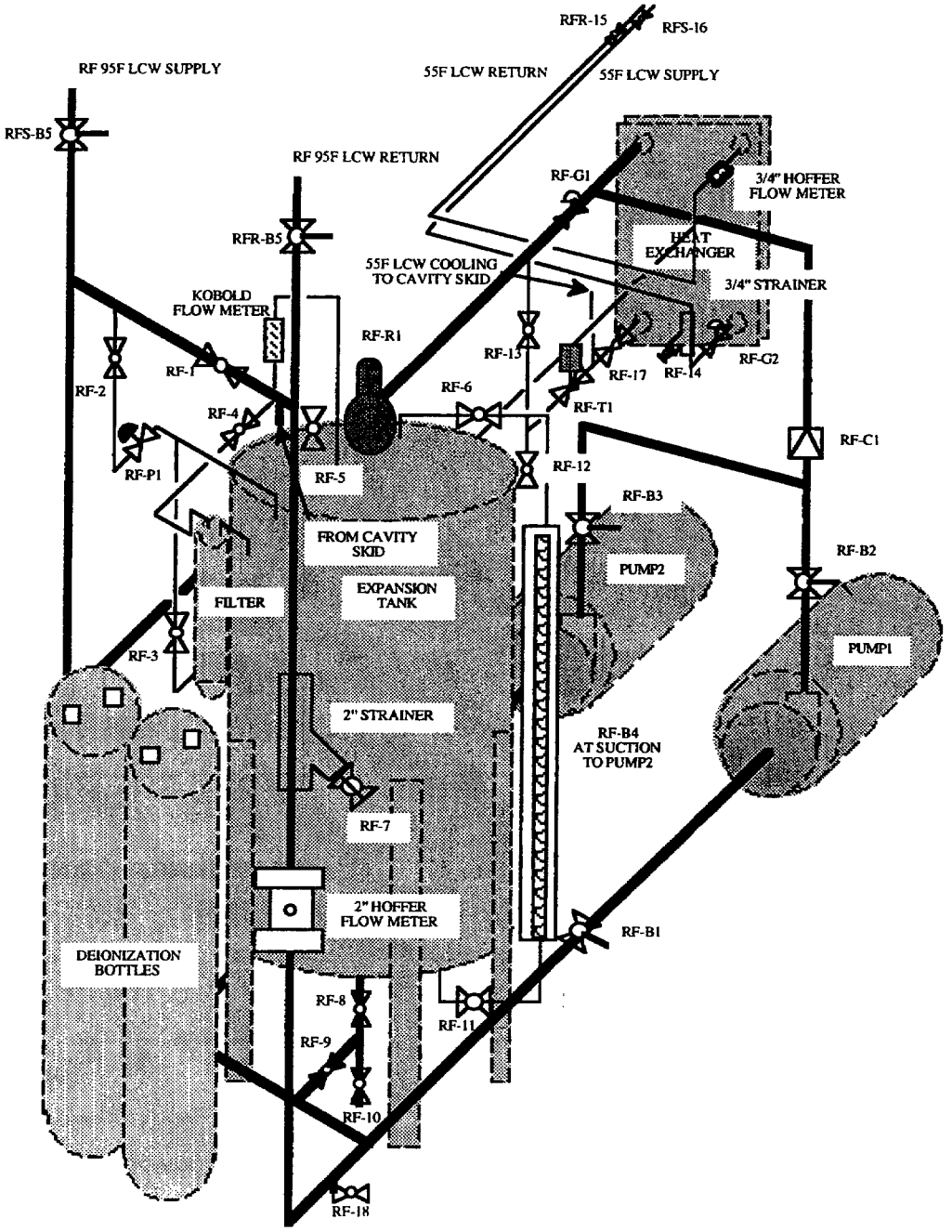


FIGURE 3 DEBUNCHER CAVITY SKID VALVE LABELS

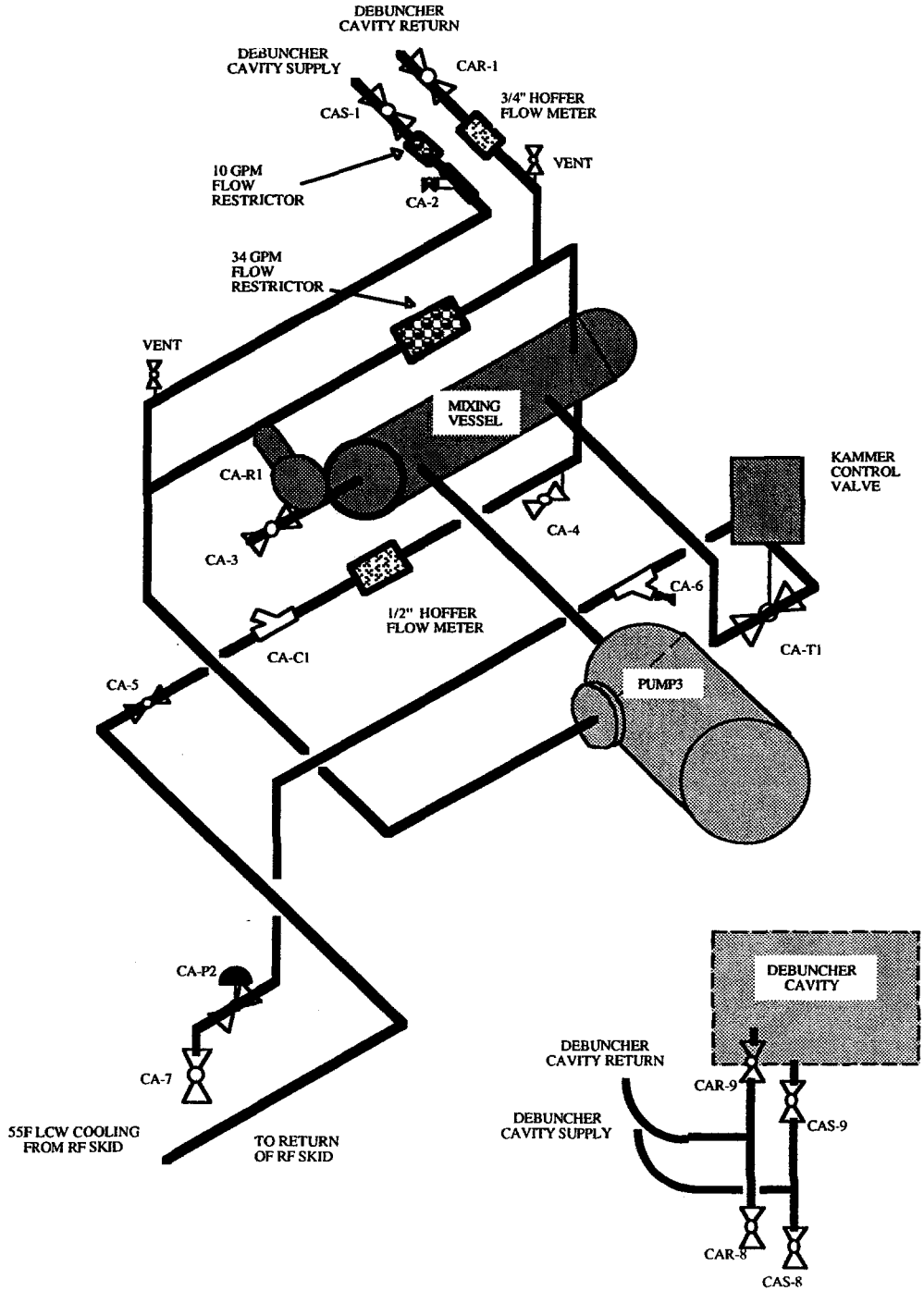
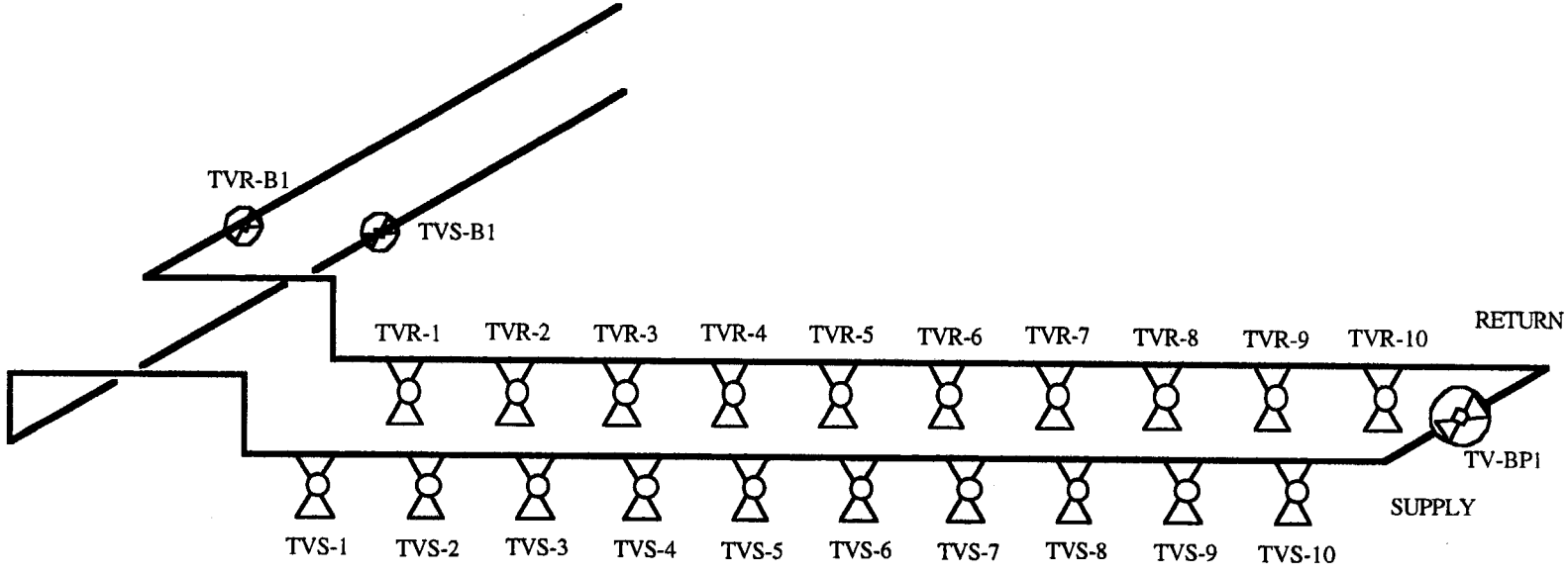


FIGURE 4 PIPING SYSTEM VALVE LABELING



4.1. LOCK-OUT/ TAG-OUT (LOTO)

Prior to most work performed on either of the two water skids in this system, the respective pump must be turned off, locked out, and tagged. The person responsible for the job must attach a proper lock and tag as designated by the Fermilab E.S.& H. department and is not to remove them until the job is complete and the system is safe to operate. Only the person attaching the lock and tag can remove them.

The Debuncher RF skid pumps are each connected to 10 Hp motor starters in NEMA 1 enclosures mounted on an attached frame adjacent to the water skids. The Debuncher Cavity skid pump is connected to a similar 3 Hp motor starter. A 30 amp circuit breaker on the backside of the frame is for incoming 480 VAC short circuit protection and must be pulled down, locked out, and tagged for the any pump or skid to be worked on. The NEMA enclosures are mounted with the Debuncher Cavity skid pump starter at the top and the two Debuncher RF skid pump starters below and are marked accordingly.

Safe maintenance can be performed on a water skid in some instances without turning off the pump. However, where lock-out/ tag-out for the pump is required, the enclosed procedures have it listed as a check item due to the dangers involved to both personnel and equipment.

4.2. STARTUP

4.2.1. FILLING SYSTEM

In the event the system is drained for maintenance purposes or another reason, the following dictates the necessary steps to follow in order to fill the system with minimum air entrapment.

CHECKLIST

_____ All valves are initially closed except RFS-B5, RFR-B5, RF-1, 2, 4, 8, 9, 11, 13, RF-B1, RF-B2, RF-B3, RF-B4.

_____ INFORM CONTROL ROOM OF USAGE OF LCW WATER FROM 55 SYSTEM.

_____ Open LCW makeup line (RF-3) into skid.

_____ Open vents in 2 inch header.

_____ When water exits vent lines, close vents.

_____ Open quick disconnect at RF-5 on tank in order to fill tank to designated level. Close quick disconnect and RF-5 when tank has reached designated level.

_____ Close makeup line valve (RF-3).

4.3. CONTINUED OPERATION

4.3.1. DISCONNECTING KLYSTRON

Valves are located at all branches from the header to the klystron to provide isolation of the system in cases where the quick disconnects may not seal properly.

CHECKLIST

_____ Close supply line valves TVS-1, 2, 3, and 4.

_____ Close return line valves TVR-1, 2, 3, and 4.

_____ Disconnect hoses at quick disconnects.

4.3.2. CONNECTING KLYSTRON

The following steps should be followed to minimize contamination of the LCW system by possible particulate which may be introduced through the added klystron.

CHECKLIST

_____ TVS-1, 2, 3, 4, TVR-1, 2, 3, and 4 must be closed.

_____ Connect Klystron body supply and return hoses to TVS-1 and TVR-1 respectively. Strainer is located on supply line. Flow meter is located on return line. (1/4 " hose is used with quick disconnect)

_____ Connect Klystron collector supply and return hoses to TVS-2 and TVR-2 respectively. Strainer is located on supply line. Flow meter is located on return line. (3/8" hose is used with quick disconnect)

_____ Connect Klystron solenoid supply and return hoses to TVS-3 and TVR-3 respectively. Strainer is located on supply line. Flow meter is located on return line. (3/8" hose is used with quick disconnect)

_____ Connect Klystron transformer supply and return hoses to TVS-4 and TVR-4 respectively. Strainer is located on supply line. Flow meter is located on return line. (3/4" hose is used with quick disconnect)

For each of the above connections, perform the following steps:

_____ Secure bucket or other means of catching water that will be released through strainer and open valve on strainer.

_____ Open return line valve and let water flush through line and out strainer valve for 10 seconds.

_____ Close and plug valve attached to strainer and open supply line valve slowly.

_____ Check expansion tank levels in water skids and keep filled to designated level by use of LCW makeup valve RF-3.

_____ Check for leaks.

4.4. MAINTENANCE

4.4.1. COMPONENT REPAIR

The following is a list of the appropriate valves as designated in Figures 2 thru 4 which are necessary to close in order to isolate the component for maintenance purposes. If available, a drain valve is also listed which would minimize the amount of LCW lost when the component is removed.

COMPONENT	DESIGNATION	ISOLATION VALVES				DRAIN
RF WATER SKID						
VERTIFLO PUMP	PUMP1	RFR-B1	RFS-B2			N/A
VERTIFLO PUMP	PUMP2	RFR-B4	RFS-B3			N/A
KAMMER TWO WAY VALVE	RF-T1	RF-G1	RF-13			RF-12
2" HOFFER FLOW METER	N/A	RFR-B1	RFR-B4	RF-8	RF-1	RF-18
		RFR-B6	RF-7			
RF 3/4" HOFFER FLOW METER	N/A	RFS-16	RFR-15			RF-14
KOBOLD FLOW METER	N/A	RF-4	RF-8			N/A
FULFLO FILTER	N/A	RF-2	RF-3	RF-4		RF-19
CULLIGAN DEIONIZATION BOTTLE	N/A	RF-2	RF-3	RF-4		RF-19
CAVITY WATER SKID						
PUMP	PUMP3	CA-1	CA-2	CA-6	CA-8	CA-5
KAMMER TWO WAY VALVE	CA-T1	CA-1	CA-2	CA-6	CA-8	CA-7
FLOW METER	N/A	CA-1	CA-2	CA-6	CA-8	CA-5
34 GPM FLOW RESTRICTOR	N/A	CA-1	CA-2	CA-6	CA-8	CA-4
10 GPM FLOW RESTRICTOR	N/A	CA-1	CA-2	CA-6	CA-8	CA-3
CAVITY 3/4" HOFFER FLOW METER	N/A	CA-1	CA-2	CA-6	CA-8	CA-4

N/A designates not applicable for designation and not available for drain.

4.4.2. SKID FILLING AFTER COMPONENT REPAIR

Once a component has been repaired in the skid, the skid will be re-filled according to the following steps.

CHECKLIST

_____ Check that all drain valves (RF-10, RF-12, CA-5, CAS-8, CAR-8) and strainer valves (RF-7, CA-2, CA-6) in skids are closed. All other valves in skids should be open except RFS-B5 and RFR-B5 or CAS-1 and CAR-1, whichever were close for the repair.

_____ Open two vents in cavity skid above mixing vessel.

_____ INFORM CONTROL ROOM OF USAGE OF LCW WATER FROM 55 SYSTEM.

_____ Open LCW makeup line (RF-3) into skid.

_____ As water exits vent lines, close individual vents and when all vents have been closed, close makeup line (RF-3).

4.4.3. DEIONIZATION BOTTLES AND FILTERS

The resistivity of the water in the system must be kept as high as possible for efficient use of the power components. When there is a drop in the resistivity, the deionization bottles and filters should be changed. A constant resistivity of at least 5 megaohm-cm must be maintained. The following procedure is for changing of the filter cartridges and deionization bottles.

CHECKLIST

_____ Close valves RF-2 and then close RF-4. RF-3 should already be closed.

_____ Drain filter and hose connecting filters to deionization bottles thru plug valve at base of filter.

_____ Disconnect deionization bottle hoses and replace bottle with regenerated one.

_____ Reconnect hoses.

_____ Replace filter by unscrewing filter body from hose connection cap. Filter is 20 micron type.

_____ Reconnect filter body.

_____ Open valves RF-4 and then RF-2.

_____ Add makeup water thru valve RF-3 as needed.

4.4.4. EXPANSION TANK AND LEVEL INDICATORS

The purpose of the expansion tank is to provide water for makeup due to a small leak and to provide a constant head on the suction of the pump. Approximately 70 gallons is contained in the tank and between 5 and 10 gallons of water is circulated after exiting the filter and deionization bottle to act as a polishing system.

A Suresite level indicator is provided on the side of the tank and three switches are mounted to the pipe containing the indicator. The uppermost switch indicates if the tank level has risen above the safe level and the lowest switch will be affected if the water level falls below a safe level. If the level rises too high, this is an indication of improper pressure distribution in the system or that the water temperature is at an unsafe level such that the water has expanded significantly. If the level falls too low, this is an indication of improper pressure

distribution once again or else there is a leak somewhere in the system. These two switches are interlocked to the pump and will shut the pump off if activated.

A middle third switch is situated just below the normal operating level. This switch is not interlocked to the pumps, but will cause an alarm light to flash if the level in the expansion tank drops. This will provide time to identify small leaks or problems in the system that have occurred before the pump is shut down.

When changes in klystrons or other parts of the system are performed, the water levels in the operational tanks may be affected significantly. For instance, the addition of a new or replacement klystron will be filled with clean water from the system thus dropping the expansion tank levels. This can be remedied by opening the LCW makeup line (valve RF-3) and filling the tanks to the designated level.

4.4.5. TURBINE FLOW METERS

Each turbine flow meter in the klystron branch and water skids consist of two main components that may fail. The turbine may become immovable due to particulates in the water or the magnetic pickup may fail.

Replacement of the magnetic pickup simply requires disconnecting the cable and unscrewing the pickup from the flow meter. Install new magnetic pickup. IMPORTANT: INSTALL MAGNETIC PICKUP ONLY FINGER TIGHT.

Replacement of the turbine flow meter requires the drainage of the attached hose. This can be accomplished by the following:

_____ Close supply line valve.

_____ Close return line valve.

_____ Remove plug from the strainer valve and crack open into a bucket to relieve the pressure in the hoses.

_____ The turbine flow meter can then be removed and replaced.

_____ Close strainer valve and re-plug.

_____ Open return line valve.

_____ Open supply line valve.

_____ Add makeup water thru water skid makeup line as needed.

4.4.6. STRAINERS

Each strainer in the klystron branch and water skid has a 60 mesh stainless steel screen installed with the exception of the 2 inch strainer at the suction to the pump having a 20 mesh screen. They should be cleaned periodically or when flow becomes restricted.

CHECKLIST

_____ Clean the strainers by removing the plug in the valve and opening it such that it flushes into a bucket.

_____ Close valve and re-plug.

_____ Add makeup water thru water skid as needed.

5. TROUBLE SHOOTING

Digital meters occupy the front panel of the water skid and are necessary for monitoring the operation of the systems. Critical characteristics of the RF and cavity systems have alarms set to notify the Main Control Room when tolerances are exceeded. Other meters provide additional monitoring and aide in tuning the system and trouble-shooting problems that may occur.

Figure 5 depicts the front panel for the Debuncher RF water skid and the location of the digital meters. These meters are listed in Table 1 with a nominal reading during normal operation of the system. The table also lists meters which send alarms and their tolerances. In order to speed corrective action when a alarm occurs, possible causes are given in the final column.

FIGURE 5

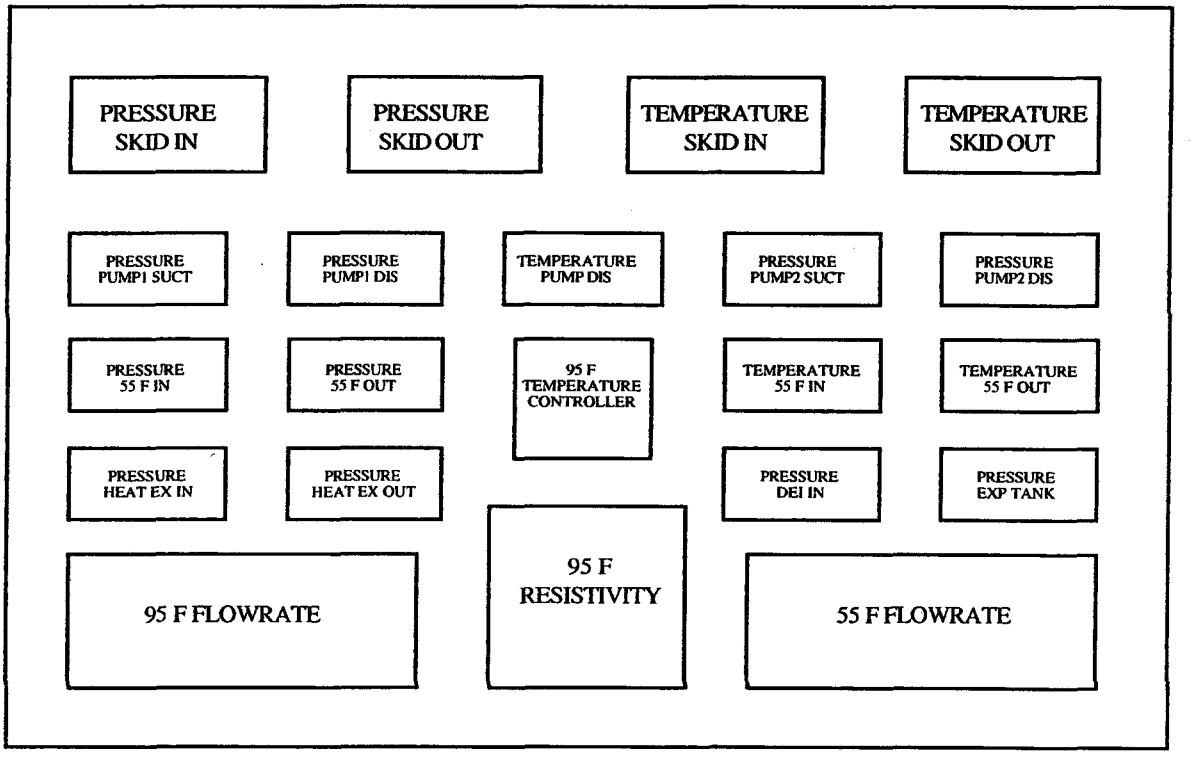


TABLE 1

DIGITAL READOUT	*NOMINAL READING*	*TOLERANCE (+ OR -)*	*ALARM*	*POSSIBLE CAUSES FOR ALARM*
PRESSURE SKID IN	2	2	YES	PUMP MALFUNCTION, LEAK IN SYSTEM, EXPANSION TANK PRESSURE TOO HIGH OR LOW, TEMPERATURE INCREASE OR DECREASE OF WATER
PRESSURE SKID OUT	74	5	YES	PUMP MALFUNCTION, LEAK IN SYSTEM, EXPANSION TANK PRESSURE TOO HIGH OR LOW, TEMPERATURE INCREASE OR DECREASE OF WATER
TEMPERATURE SKID IN	95	5	YES	CONTROLLER MALFUNCTION, HEAT EXCHANGER NOT COOLING PROPERLY, CHILLED WATER PROBLEMS, GLOBE VALVE (RF-G1) OPEN TOO MUCH PROVIDING SHORT CIRCUIT
TEMPERATURE SKID OUT	94	5	YES	CONTROLLER MALFUNCTION, HEAT EXCHANGER NOT COOLING PROPERLY, CHILLED WATER PROBLEMS, GLOBE VALVE (RF-G1) OPEN TOO MUCH PROVIDING SHORT CIRCUIT
PRESSURE PUMP1 SUCTION	3	NA	NO	
PRESSURE PUMP1 DISCHARGE	86	NA	NO	
PRESSURE 55 F IN	130	NA	NO	
PRESSURE 55 F OUT	29	NA	NO	
PRESSURE HEAT EX IN	88	NA	NO	
PRESSURE HEAT EX OUT	56	NA	NO	
TEMPERATURE PUMP DIS	97	NA	NO	
PRESSURE PUMP2 SUCTION	11	NA	NO	
PRESSURE PUMP2 DISCHARGE	11	NA	NO	

TABLE 1 (cont'd)

DIGITAL READOUT	*NOMINAL READING*	*TOLERANCE (+ OR -)*	*ALARM*	*POSSIBLE CAUSES FOR ALARM*
TEMPERATURE 55 F IN	54	NA	NO	
TEMPERATURE 55 F OUT	70	NA	NO	
PRESSURE DEI IN	8	NA	NO	
PRESSURE EXPANSION TANK	3	NA	NO	
95 F LCW FLOW RATE	60	10	YES	STRAINER NEEDS CLEANING, MAGNETIC PICKUP FAILURE, FLOW METER MALFUNCTION, HEAT EXCHANGER NEEDS CLEANING
95 F TEMPERATURE CONTROLLER	100 SET POINT	NA	NO	
95 F RESISITIVITY	18	5	YES	DEIONIZATION BOTTLES NEED REGENERATION, SYSTEM BEING CONTAMINATED
55 F LCW FLOWRATE	5	1	YES	STRAINER NEEDS CLEANING, 55 F LCW SYSTEM MALFUNCTION, MAGNETIC PICKUP FAILURE, FLOW METER MALFUNCTION, HEAT EXCHANGER NEEDS CLEANING

NOTE: NA DESIGNATION SPECIFIES NOT APPLICABLE